TECHNOLOGY DEPT

EDITION B

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MAY, 1943

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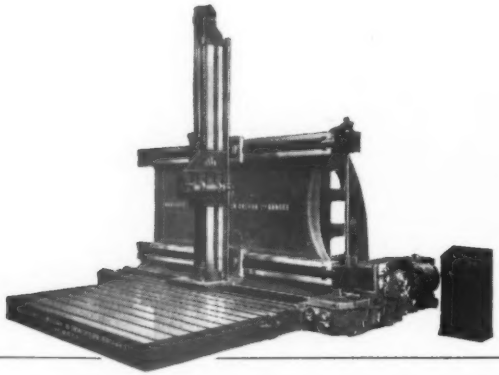

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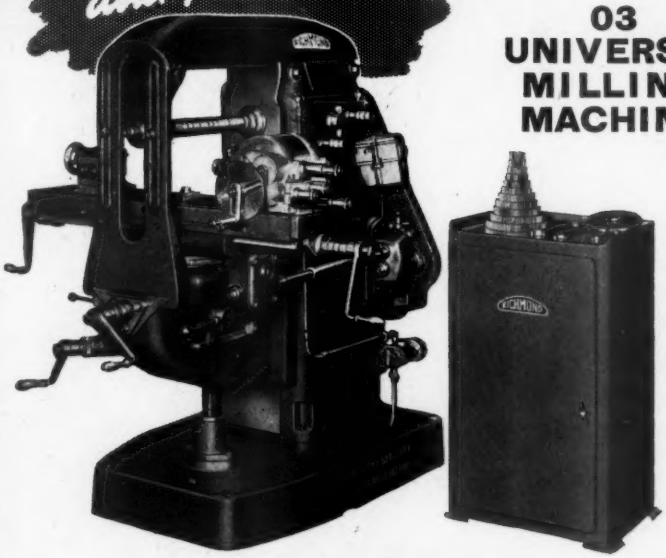

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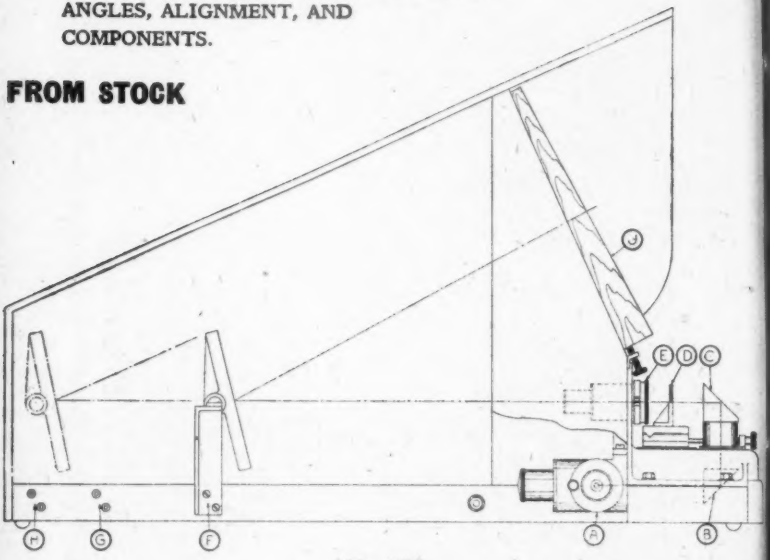

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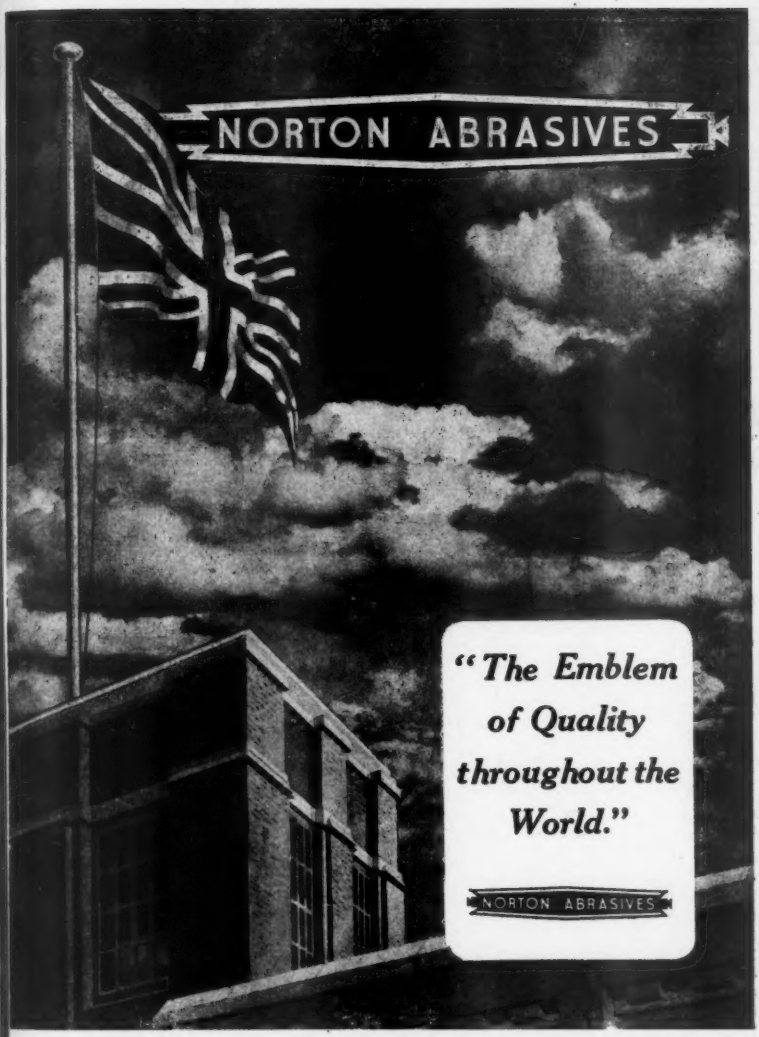

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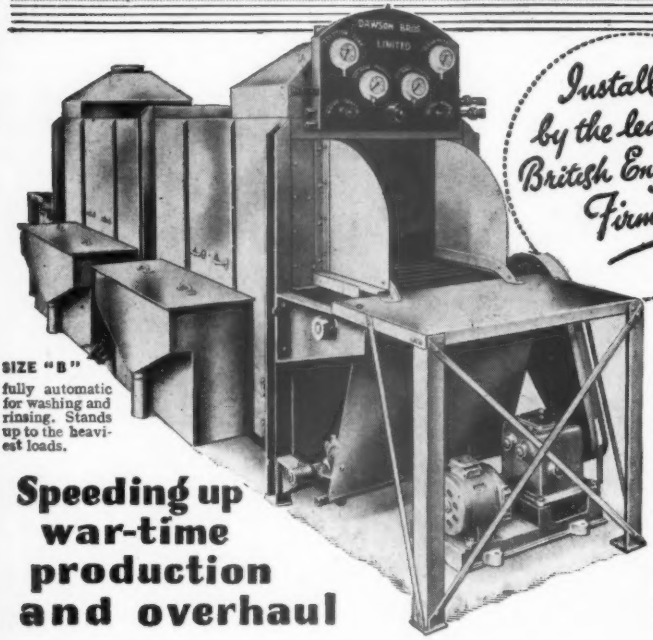

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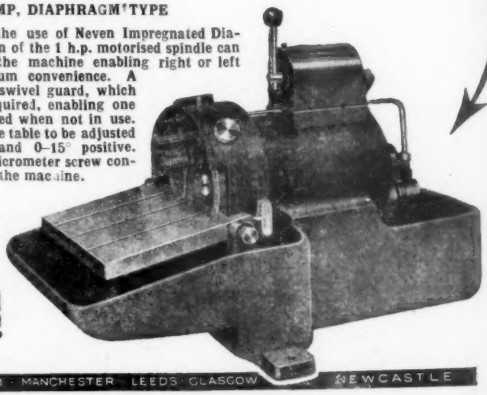

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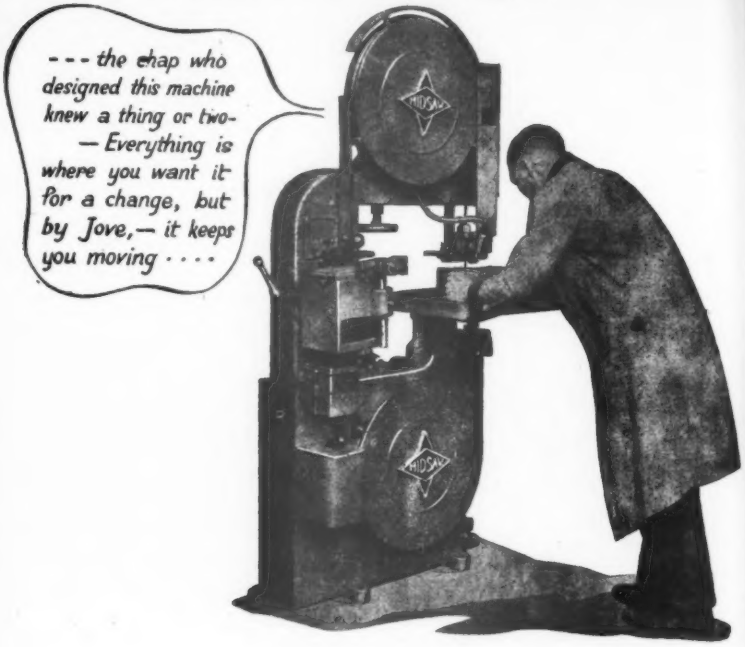
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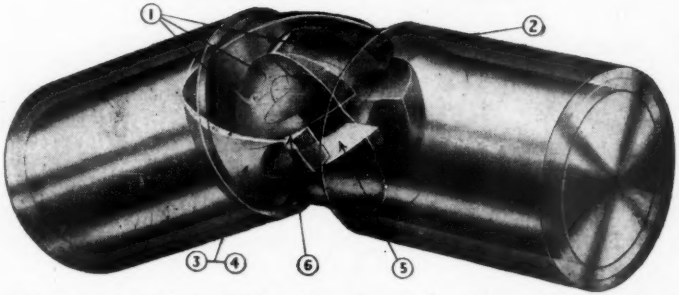

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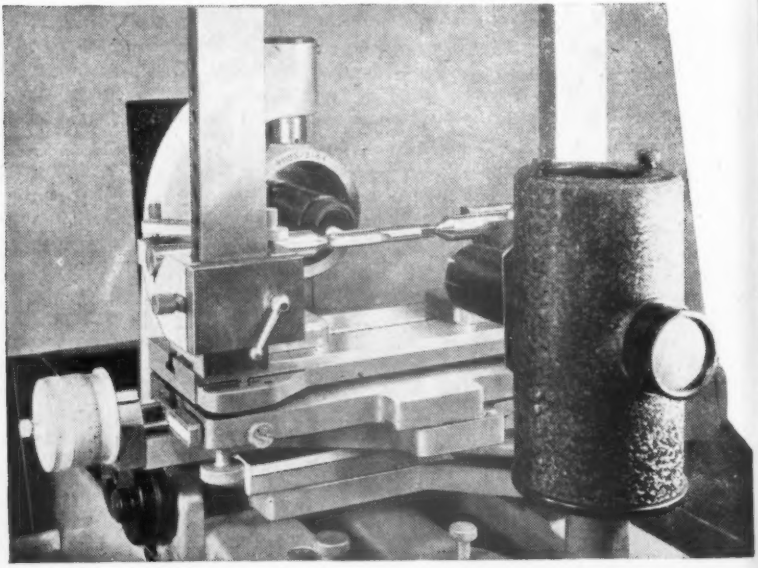

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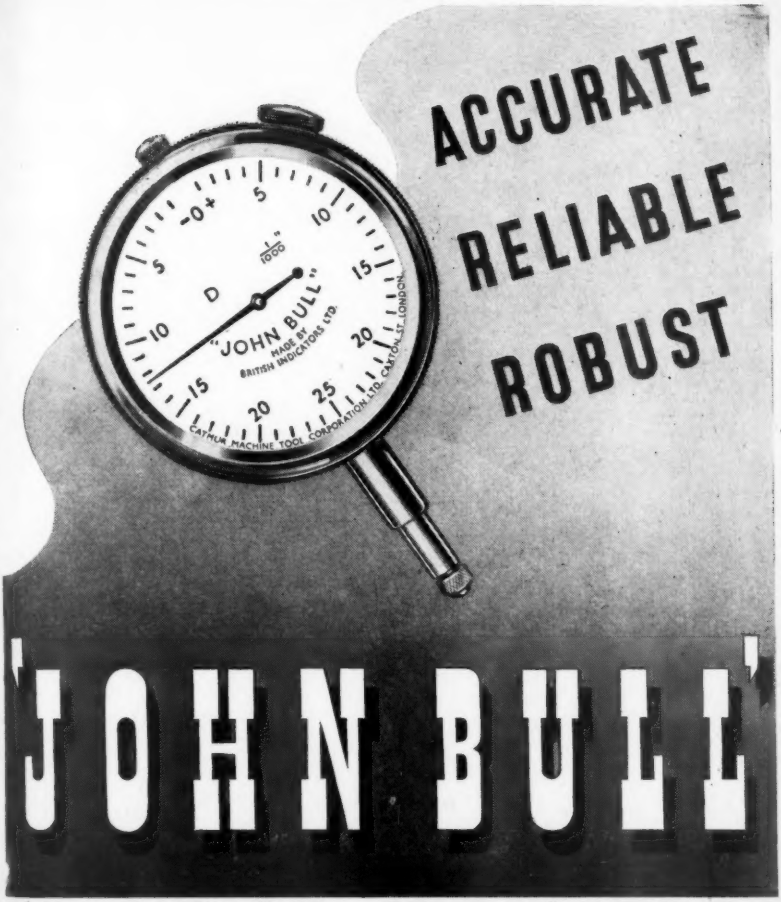

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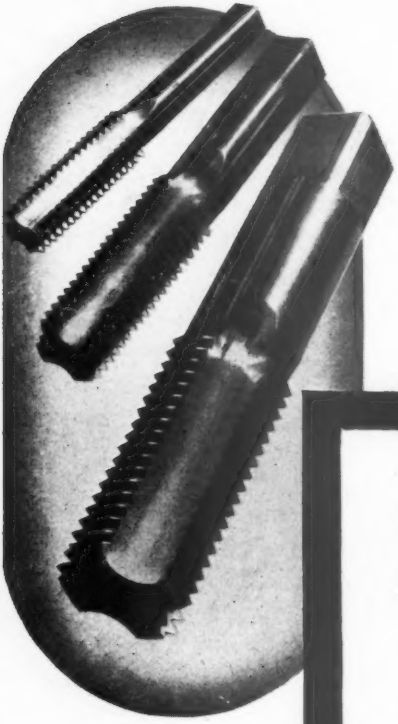

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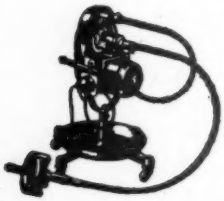

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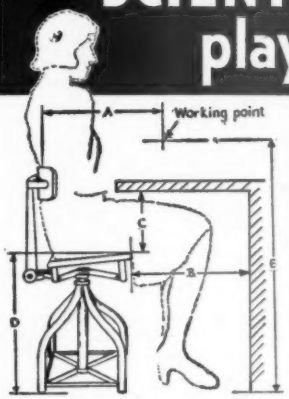

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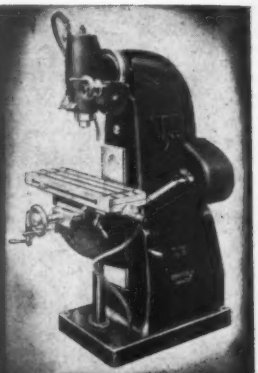

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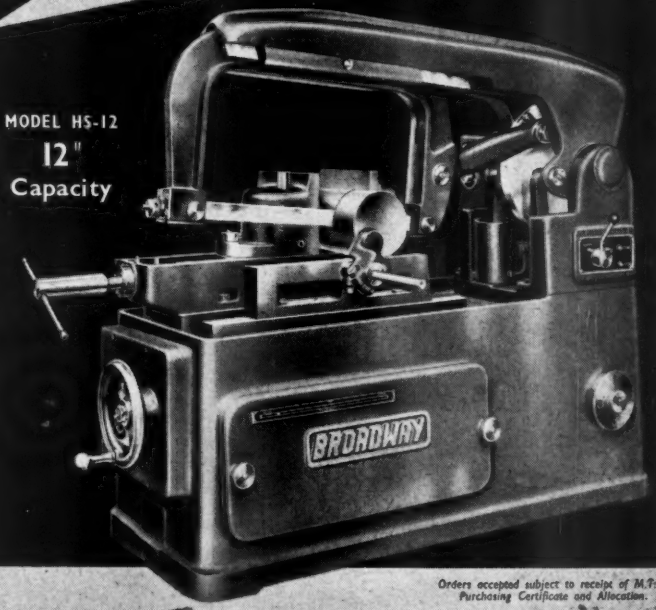

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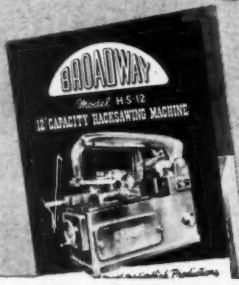

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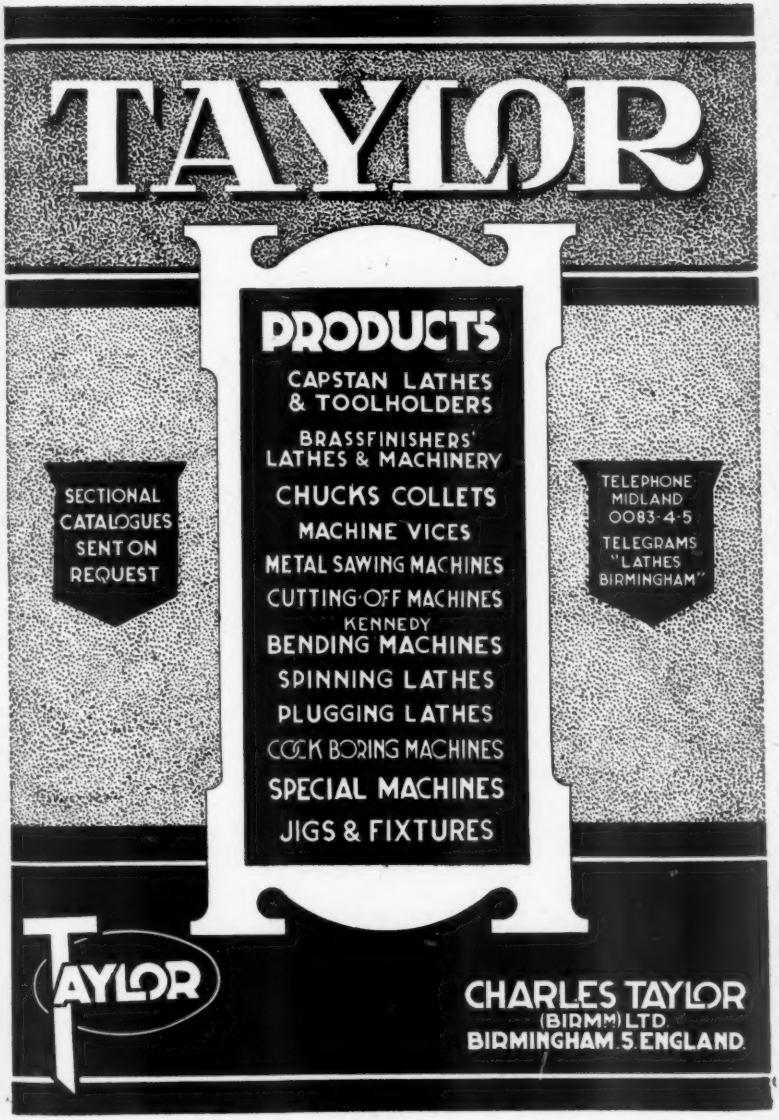
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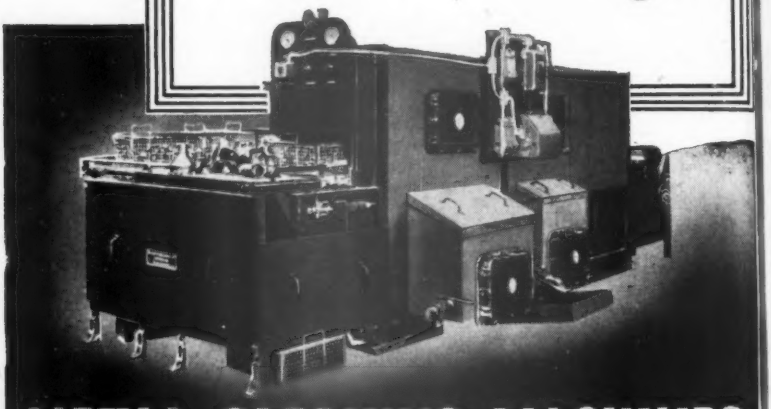

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PRODUCTION CONTROL

Paper presented to the Institution, London Section, by R. Appleby (Associate)

A MEETING of the London Section of the Institution was held at the Institution of Civil Engineers, on Wednesday, the April 21, 1943, at 7-0 p.m., when Mr. R. Appleby, A.I.P.E., gave an address on Production Control. Mr. R. Kirchner, M.I.P.E., Section President, was in the Chair, and between 250 and 300 members and visitors were present. The Address was followed by a Discussion.

In opening the Meeting the Chairman referred to a meeting of the London Section held in January, 1942, when the subject under discussion was " Production Control " and mentioned the divergence of opinion disclosed at that time as to the precise meaning of the term, and the necessity for agreement on this. He explained that as a result of this meeting the Institution formed a Production Control Committee under the chairmanship of Mr. T. W. Price, and this Committee felt that their first task should be to consider fundamentals and arrive at universally acceptable definitions. In introducing Mr. Appleby, the Chairman said he had already addressed a number of Sections of the Institution on Production Control, and in all cases the meetings had been most successful. The paper Mr. Appleby would read that evening represented the development of the work of the Production Control Committee to the present stage, and the influence of the discussions which had taken place in the Sections.

Mr. Appleby thanked the Chairman, and expressed his appreciation of being given the opportunity to address the London Section. Before reading his paper Mr. Appleby stressed the importance of considering the subject from the practical rather than the theoretical angle—what really takes place in practice. He also emphasized that his remarks applied equally to the small as well as the large firm. Mr. Appleby then read his paper.

It is impossible to deal with the subject of Production Control in detail because of the variety of techniques which obtain in any factory according to its size, shape, and the work it is doing, but I will attempt to cover the subject under these headings—What is Production Control? Production Control problems in Wartime. What is its place in the organisation? Some considerations in setting up Production Control. Some considerations of each aspect

of its machinery, and finally : Some implications which are particu. larly important for this Institution.

I well realise that to cover so wide a field limits the extent of detailed considerations, but, as I have already mentioned, these vary so very much according to circumstances that they could not be treated adequately in one evening.

What is Production Control ?

Production Control is an industrial term, and the person using it imposes upon it limitations which are consistent with what he considers to be the boundary lines. Very often these boundaries are not ideas which have taken shape as a result of a detached and analytical approach. On the contrary, the mental picture of the Production Control function usually assumes its shape as a result of the particular experience or industrial background. Naturally, the basic similarity of industrial experience is such that there is bound to be a degree of uniformity amongst the interpretations of individuals with this experience. Unfortunately, however, there are so many different focal points within these degrees of uniformity that there are shaded edges to the substance of agreement, and when discussions take place these shades of difference cause considerable confusion. We must accept, however, that in principle production control cannot have more than one agreed interpretation.

The term is also somewhat anomalous, for Production Control is only one of the instruments by which Production is Controlled, and Control in the general sense is nothing new.

This is explained by the fact that if we take any productive process, no matter how simple, we shall find that Control always exists.

By using the example of a man driving a nail into a piece of wood, it is obvious that he controls his hammer. The point of importance for us is that the greater the degree of Control he exercises then the more effective will be his act of Production.

The fact that control of this sort is sub-conscious is irrelevant. Furthermore, this element of control applies to everything we do, but as production becomes less dependent upon individual effort, the close and often sub-conscious connection between control and production becomes less apparent, until eventually we reach the stage in the most complex processes where the direct relation is almost impossible to trace.

In effect, what happens is that this introduces control of a high degree by more than one individual. Now, whilst it may be quite true that each of the individuals concerned performs his particular act of production by the exertion of a sub-conscious technique which determines the degree of control, a further condition has

imposed itself, which is that these individuals must be regulated or co-ordinated, and this co-ordination is not, and cannot be, sub-conscious.

There are, therefore, two categories of control.

The first is that which is a part of, and cannot be divorced from, the individual.

The second is the conscious regulation which must be exercised whenever individuals have to be co-ordinated in production processes.

In any condition of production this applies, and therefore in every factory in the country, no matter how inefficient and even though the term Production Control has never been used, Production is Controlled.

If this is true, why should there be so much controversy? The answer is that we are concerned with the degree of control rather than with control in the absolute.

It is interesting, and I think well worthwhile, to trace the history of the growth of Control in industry which has brought us to the present position, for it is very relevant to a settlement of what Production Control really is.

After the industrial revolution which brought with it the factory system and, ultimately, the industrial organisation with which we are all familiar, many economists attempted to define the basis of an industrial economy which they expressed as factors of production. Now it is significant that the early economists considered that there were three factors—namely, Capital, Land, and Labour. Later, however, the question arose of a fourth factor, but this was not clearly defined until the 1880's when Marshall said that this fourth factor of production was Organisation.

At first, organisation dealt with the larger and more general problems which a growing technology and complexity of product demanded, but eventually it became more specialised, and ultimately gave rise to the science of management. Production Control is part of the science of management, and the reason that we are so much concerned about it to-day is not because Control did not exist prior to its considerations, but because the complexity of production has forced upon us the ever-increasing necessity for a greater degree of premeditated Control and a consideration of the technique of its application.

As I have already mentioned, there are two categories of Control, and with the control by the individual over his acts of production we are not concerned. This is the job of Motion Study, etc.

We are concerned with the technique of control which has developed from organisation and of which it is a part, and because of this, Control is probably not the best means of expressing what we have in mind, for although I have said that there are two categories,

this is merely a concession to accepted terminology, for in the last analysis, Control cannot, in any circumstances, be removed from the individual, and the Control we are considering to-day is a means by which individuals can exercise control rather than a method which attempts to remove it from them.

May I illustrate this point. When an instruction is given by an individual, he can give his instruction verbally, and in this case the voice would be the medium of Control. Individuals cannot exercise control by verbal methods because the vast amount of information which must be available could not be conveyed in this manner. The medium has, therefore, to change to written instructions and information. To-day there are so many written instructions that their issuance and co-ordination, their timing and their authority have in themselves become a speciality.

Control is, therefore, the speciality of organising this medium of expressing control. It is the machinery of co-ordination.

Having specified the limits to be imposed upon the interpretation of the word " Control," it is necessary to define " Production " in a similar manner.

No doubt the application of principles of the form of Control envisaged by the above definition could be made without difficulty to all production processes, such as Coal Mining, Smelting, Agriculture, Food Processing, etc., but to agree to so broad an interpretation would be to make the field of survey limitless.

Academically it would be correct to include these, and other processes, within the field of application, except for one thing—the term Production Control has not arisen as a result of the development of a specialised control technique in the processes mentioned a moment ago.

The term has arisen because a technique has developed out of the complicated processes in certain production spheres involving the determination of factors, which, because of their complexity, are not easy to assess accurately.

These processes are the engineering productive processes as distinct from others, and therefore we must confine our enquiries to this particular field ; in fact even within this field of research there are a number of groupings which demand special treatment.

Production Control is, therefore, that part of management science, which is concerned with the correct degree and the medium by which Control can be exercised in the co-ordination of the productive resources available in an engineering productive unit.

I hope that the case which I have made in support of this definition is such that it provides a sound basis which will stand the test of analysis.

This definition must now be turned into practical terms because it imposes a function on the term Production Control, and we must see how this function could be operated and whether the machinery of operation fulfils the conditions laid down.

One very important conclusion emerges immediately, and this is that Production Control in being pre-determined control, must lead to planning in this sense.

No method of production to-day is so simple that entire control can be exercised by verbal instructions. Certain information must be put on paper. Consequently the first requirement of Production Control is that it should be able to translate engineering information into parts and assemblies in the most suitable manner.

As it is purposeless to issue information which cannot be carried out, it follows that Production Control information must be issued in accordance with known conditions of capacity and requirements against that capacity.

Consequently Production Control must have as its foundation a predetermined plan of production which, based on engineering and other information, has taken account of the physical capacity of the production unit. It must then be able to set the capacities in motion according to this plan.

A further condition therefore emerges, for to enable the above requirement to be fulfilled, Production Control, amongst other things, must use the information of what has taken place in the past, in order correctly to forecast what is likely to happen in the future under similar conditions.

This means that Production Control information must be so organised that it provides for adjustments to the production plans of the present and the future, according to the physical variations which are continually taking place. In other words, one aspect of Production Control is that it must reflect the physical movement of labour, material, and machines. The importance of this clerical reflection of physical movement cannot be overstated because of the fact that the greater the number of variations the more difficult it becomes to deal with them.

A final requirement is now imposed for if Production Control is to be the hub of maintaining production programmes. It must be the means of informing and authorising individuals in the discharge of their responsibility and placing in their possession knowledge which will enable them to exercise control.

It must, therefore, be the nerve centre of information relating to planned production from all sources, and it must be able to segregate and analyse this information, assess its effect on production, and re-direct such information into the necessary channels.

These conditions are best dealt with by summarising them into specific categories which are five in number :—

1. Production Control must be able to plan according to requirements and capacity.

2. It must be able to co-ordinate material and tool requirements so that these are available for production to proceed.

3. It must be able to dovetail the work which the plan comprises into the machine and operator capacities and keep them fully occupied.

4. It must place in the hands of responsible individuals all the information concerning production in its relation to the plan, to enable them to carry out their part of it.

5. It must be able to guide production once set in motion towards the completion of the plan, take account of variations therefrom and also deal with their effect on present and future production.

To fulfil these conditions Production Control is divided into two main groups. The first comprises those functions which are purely Production Control, and these are five in number. The second group is comprised of various aspects of a manufacturing unit which are principally concerned with some other activity, but which are used to provide information to enable Production Control to operate.

Dealing first with the purely Production Control components, these are :—

1. *Capacity Utilisation.* The means by which time factors of control, engineering and productive functions are measured and utilised in the formation of a plan ; also corrections recorded and reflected during its operation so as to allow of its fulfilment.

2. *Schedules.* The means by which the production plan is presented to all concerned to provide for the commencement and completion of work in all stages of manufacture.

3. *Stock Control.* The means by which the correct quantity and quality of materials and components are made available according to the production plan.

4. *Manufacturing Orders.* The means by which authority is given to all concerned to produce according to plan.

5. *Progress.* The means by which the execution of the production plan is co-ordinated so as to reveal, and as far as possible to eliminate or correct, any variations from the plan.

Dealing next with the functions which are not purely Production Control, we shall see that they fall into three main categories.

The first is the direct production function.

The second is the engineering function.

The third is the financial and commercial function.

All of these have a number of components, some of which could be mentioned, such as ratefixing and time study, routing and processing, jig tool and test gear design, inspection, stores, purchasing, labour, costs, budgetory control and standards (material and components). Their relationship can best be clarified by giving some examples.

The manner in which the accountant builds up his costs is not necessarily the concern of Production Control, but the manner in which the costs are used for reflecting variations from the plan is an important control element.

The method of purchasing may not be the concern of Production Control, but it is its responsibility to see that information to enable purchasing is in the hands of those concerned, and to know that this is being carried out in accordance with the plan of production.

The fact that jigs, tools and fixtures are designed for a process is a technical matter. Production Control will discharge its responsibility providing it collates all the information relating thereto in order that the jigs, tools, and fixtures will be available at the point of process when they are required.

It will be noticed that there has been continual reference to functions, and any mention of departments has been avoided. This is deliberate for we are not interested in divisions of responsibility, but in the fundamentals of Production Control. Naturally, divisions of responsibility along the same lines as these functions is at all times desirable, but is not always possible, and is a further issue which will be dealt with later.

Production Control in Wartime.

There is no need to expand at great length on the problems of production which are peculiar to wartime, but some of the major aspects of the difficulties could be mentioned. For example :—

The vast increase in engineering capacity as a whole.

The increase in precision work and the more complex production processes.

The new factories, large, and particularly small, which have been established.

The supply of materials.

The link with the state machinery.

The shortage of skilled labour.

Part time workers and outworking.

The flexibility which the continually changing needs of the Services involves and the consequent inability to lay a job out in the normal manner.

And, finally, and probably most important of all, the shortage of competent industrial managers, and administrators, and the very

haphazard methods of selection for supervisory positions of all grades.

We are all familiar with difficulties which such conditions in combination can produce, and it needs to be emphasized that the solution of these problems cannot be achieved by installing some type of Control. On the other hand it also must be emphasised that without Production Control each of these will be even more difficult to handle than would otherwise be the case, for it does place before the factory manager as full a knowledge as is possible of the factors which are most likely to be affected by any course of action either within or outside his control.

What is the Place of Production Control in the Organisation.

There are four basic functions in production as follows :—

The first of these is Production Engineering which deals with all the activities of the technical departments, such as :

(i) Preparation of design for manufacture.
(ii) Rates and Time Study.
(iii) Engineering estimates.
(iv) Process layout.
(v) Jig and Tool design, etc.

The second is the Control function which covers Planning and its five components as already mentioned. Incidentally, I do not here refer to Planning in the engineering sense but to the drawing-up of programmes, etc.

The third is the Works function which is concerned with manufacture according to the programmes of the Control Department and in conformity with the specifications of the Engineering Department.

The fourth is Inspection which is concerned with maintaining the standard of production according to the limits imposed by the specifications and drawings of the Engineering function.

As far as possible departmental responsibility should be along the same lines as indicated by these divisions, but this is not always practicable, particularly in the smaller firms where the Engineer might also be the Works Manager, and where a number of departmental responsibilities may have to be vested in one individual.

Clearly it is impossible to be dogmatic about these, but the most important aspect of the matter is this—Where the division can be achieved it should obtain because by doing so it will be possible to bring the necessary weight to bear upon each activity.

It often happens that a lack of appreciation of these fundamentally different aspects of Production cause one to be subordinated to another and this more often than not involves the subordination of

the control function. This is fatal and can only result in conditions similar to examples I shall quote later on.

Whatever size the manufacturing unit, these four activities should in turn report to an over-riding authority not responsible directly for any one of the four, but in a position from which the wider viewpoint, which is implicit in Production Organisation, can be taken.

The relationship between the commercial and financial departments has already been discussed, but there is one aspect of purchasing which needs further mention.

In that Production Control is responsible for progress in the works it is necessary to state that it does not follow that it should be responsible for outside progress. Outside progress is so much concerned with commercial policy that as a general rule the Purchasing Department should be made responsible for its own progressing and for seeing that the materials required are delivered according to the schedule of the Production Control Department.

The relationship with the Sales Department is perhaps most important of all. We all know of the Sales Department which is inclined to accept orders without consulting the Department which should know whether the order can be executed, and we are all familiar with the consequences.

Unless we are prepared to give the Production Control activity its proper status in relation to the other Departments we shall continually be faced with this problem. For in fact the subordination of the Production Control function implies a subordination of the organisation factor in industry, and organisation should not be subordinate.

Some Considerations in Setting Up Production Control.

There are one or two stock arguments which need to be answered if we are to start with a correct approach to the establishment of a Production Control Department. Two of these arguments are (a) Expense, and (b) Paperwork.

The fallacy which gives rise to the view that Production Control is an expense is based on the belief that it is a mysterious technique, when in fact it is plain commonsense. Perhaps I should say organised commonsense. How can a technique which reduces waiting time, machine idling time, confusion, material hold-ups, etc., to a minimum be a mysterious technique and an unjustified expense? Such an argument carried to its logical conclusion would deny the necessity for Organisation.

The other argument, that of paperwork, also has its roots in expense and the fear of complicated systems. So far as paperwork is concerned it may mean that when you instal Production Control you will realise for the first time how much paperwork you actually

have in your works, merely because you organize it properly. It may also mean that by organizing your paperwork you will eliminate a large number of cubby-holes where scrap pads and scribbling notes thrive, and you may also find that in total you have saved on clerical work itself if you can determine, at the outset, exactly how many pieces of paper are really needed for a job, and prepare them all at once, rather than have an assortment of people copying this, that, and the other, at various stages of production, and trusting that the information reaches everyone concerned.

These two mental obstacles must be cleared from the minds of those operating Production Control if it is to be at all successful. Furthermore, it must not be overlooked that Production Control is not operated by people sitting in offices with fancy ideas. It is operated and dependent for its reality on the clerks, storekeepers, progress men, chargehands, setters, etc., out in the shops where the work is taking place, and unless these people can be carried along with the management in any organization it is bound to fail.

The way these people can be made into active supporters of Production Control is to tell them what it is about and consider their criticisms which are more often right than wrong.

As for complicated systems there is nothing more complicated than a system which is a hotch-potch of half measures, a system which is not controlled. Production Control aims at the simplification of systems. These two bogies are the first which must be run to earth if any headway is to be made ; reservations about them are bound to influence its operation.

The next stage is to examine the basic functions of Production Control which have been mentioned individually, and see them in their correct perspective. This perspective is that they are always a means to an end—maximum production.

Capacity Utilisation.

The first of these, and without doubt one of the most important, is Capacity Utilisation. Without Capacity we cannot produce. Only a true measure of Capacity will enable its Utilisation to the fullest extent.

The difficulty with Capacity is that it is made up of so many parts—some tangible, and others less so. Machines, Labour, Space, Experience, Technique, Management, and so on.

Moreover, Capacity does not exist solely in the production shops—it exists everywhere in the plant where there is any activity which bears upon, and influences production. In the Drawing Office, the Engineering Department, the Planning Department, the Tool Room, the Print Room, the Typists' Pool, etc. In the Purchasing Department, the Maintenance Shop and the Stores.

We must break away from the idea which causes orders to be accepted merely because plant is idle ; when the job which is accepted cannot be put through the Production Engineering Department because of modifications which are necessary before it can go to the shops.

Hundreds of delivery promises are broken long before a job ever reaches the Manufacturing Departments because of this. And to what effect ? Chaos !

A plan of production is a useless document unless it has taken account of the physical limits of Capacity. The best way of describing a sound production plan is to say that it represents what is required, modified by what can be achieved.

Unfortunately it is so much easier to say what is wanted than to reconcile a target with the available Capacity, simply because Capacity is not always easy to measure.

To modify our requirements to suit our physical limitations is distasteful, but we must face reality early in the design of our plan, for unless we do we shall find that the physical conditions will impose their own limitations when it is too late to alter the whole to suit this forced imposition. The inevitable consequence is that production becomes unbalanced.

Take machines as a case in point. How many firms really know what their machines are doing in the course of a day ? How often it happens that machines are overloaded one day and underloaded another. It seems inconsistent that we watch the time spent by operators from 6d. per hour upwards in the most diligent manner and knock off quarters, etc., for lateness, yet with machines which may be costing as much as 10/- or £1 per hour and which may represent a considerable proportion of a firm's capital, we do not appear to be as interested in the quarters they are idle as we should, all of which become a dead weight on the quarters they are working.

The same in fact applies with the real effectiveness of our labour. Granted that we clock them on and off, how many units really know the effect of their labour output when progress men, foremen, managers, chargehands, etc., are scrambling to meet impossible delivery dates ? How many units know how much production per man hour falls, when machines are being run on short running jobs because panic action is needed somewhere ? How many firms have actually assessed the downward effect on production when setters and operators are being badgered by high-powered chasers who are working from the wrong end of the stick because of some previous bad scheduling ?

Much the same applies to ratefixing, and it is surprising how little is known as to the comparative efficiency of the Ratefixing Department in relation to rates set against actual machine and operator performance.

Scheduling and Manufacturing Orders.

The best production plans will break down unless your schedules and orders or, as they are often called, shop programmes and work tickets, express in detail what the production plan states as a whole. These documents are the manager's and the foreman's lifeblood. They should tell him what he has to do, when he has to do it, the time he is allowed, where the job comes from and where it goes to.

They should also be the documents which enable stores, progress, setters and chargehands to operate. They must, of course, take account of shop load, tools, and the material position, and this information must be determined before their release to the shops. Consider the inconsistency of the position which allows an order to go to the shops for parts to be produced by a certain date, and when the foreman applies for his material it isn't there, or the tools are not ready.

Of course, it would be undesirable to try to make paperwork do the foreman's job for him, and therefore he must be allowed certain flexibility in arranging the sequence of his orders in the shops to the best advantage, provided that this flexibility is within the framework of the main plan.

Production Control would strangle itself if it did not allow for this, but we must insist that within the main plan or schedule the foreman and his clerk arrange for an organized flow of work through the departments. This applies particularly to batch machine shops. If this isn't done, it will be found that chargehands and setters, when left to their own devices, will select all the best paying jobs and leave the short runs and difficult set-ups, etc., till later. Later than is convenient. Setters should not be allowed flexibility as to which job they should set. On each machine, or group of machines, there should be a card or board which states the programme for that machine during the coming week, or any other period which is considered convenient.

Finally, and as already mentioned, don't rely on schedules and orders getting to the right people. Organise their distribution, and print them for them.

Stock Control.

It is important that, in considering Stock Control from the Production Control viewpoint, we are quite sure what is meant by this term.

Stock Control is often confused with Stores Control, and I wish to make a clear distinction between the two. The view I wish to put to you is that Stores Control is concerned with the handling of materials, binning, racking, receiving, issuing, etc., but that Stock Control is concerned with the actual control over the amount of

stock which should be held in stores for particular requirements. It is quite possible that the two functions of stores and stock control may be exercised by one individual, but it is not always to be recommended, particularly in the manufacturing concerns where the physical size of the stores is such that the control of labour and the administration of stores is a speciality in itself, and where the control of stock against particular contracts is a clerical job performed by the Production Control Department. The reason for making this distinction is to draw a clear line of demarcation between clerical and physical work.

If this principle is firmly established then it follows that the clerical control of stock will be vested in an individual belonging to the Production Control Department which, in turn, must mean that this aspect of organisation will receive the weight it deserves and, furthermore, will enable a concentration of supervision which is not influenced by staff worries, etc.

We all know how easy it is for records of stock to spring up in numerous places by different individuals keeping a few cards so as to know their own position. This is bound to result in clerical discrepancies and should be ruthlessly eliminated.

Accurate and up-to-date records are the key-stone of successful Stock Control, but how often does this apply ? How many times does it happen that we are not aware of a material shortage unless a machine comes to a stop, or operators are standing idle ?

How often does it happen that our empty stock bins are the first indication that we should re-order Material or Components ? And how often does this result in a scramble for Materials which involves not only one department or one firm, but many departments and many firms in taking exceptional measures to keep Production going. And how often do these self-same exceptional measures reflect themselves in an accumulative manner on half a dozen other jobs at a later date without any warning, due to the fact that there was no method of measuring the damage that such exceptional action has on future Production ? And how often does exceptional action of this nature become so much an everyday occurrence that staffs have to be increased to deal with it until ultimately foreman, progress men and chargehands, etc., are falling over themselves and everbody else in an effort to keep production going, and costs mount up and real Organisation becomes unknown ? All because we had insufficient knowledge of our Material and Stock position.

Often in the case of material our lack of knowledge is something beyond our own control particularly in present circumstances when transport and other factors have a serious influence on delivery dates, but very often material delivery dates break down for the simple reason that the firm giving the date has done so by guesswork.

Progress.

I am afraid that my remarks in connection with the progress function are not going to enhance my popularity with members of Progress Departments who are present. Notwithstanding this, I must say that the progress activity has been very much over-done in recent years. This does not mean to say that progress has not a very important part to play in Production Control. It has. But the Progress department is often turned into a Chasing department.

Bad planning, incorrect scheduling, and lack of co-ordination of material delivery dates, flow of parts, and lack of accurate stock records cannot be overcome by increasing the progress staff. The only effect this has is to continually badger foremen and charge-hands to achieve the impossible.

It is often said that the efficiency of a Progress Department is denoted by the number of Progress personnel in relation to other employees, or to the amount of work which is flowing through the factory. And this is true up to a point. But whatever the standard which is applied to the efficiency of progress—and this is certainly very difficult to establish because the standard would vary as between shop and shop, and factory and factory—it is important that we see the Progress function in its correct perspective as the pointer which indicates where something is likely to go wrong rather than as a growing activity which thrives because everything has gone wrong.

How Does Production Control Operate.

So far my remarks have been very general, and I have tried to show what Production Control is. What it comprises. Its status in the organisation, and some of the difficulties which arise through its absence. I have also tried to focus each of the Production Control sections in their correct perspective.

In attempting now to give an outline of operation—no matter how sketchy—I realise that I am putting my head right into the lion's mouth for the very reason which I mentioned in my opening remarks.

The natural reactions which will arise from my following comment fall into these categories :—

We don't do it that way.

It wouldn't work like that in our factory.

This record has been missed or that department has not been referred to, etc.

This is too simple, or that is too complex, etc.

Despite this I intend to risk the danger of appearing to be particular, when in actual fact I still wish to keep my comments general.

My reason for so doing is that I am most anxious to avoid the impression, by what has already been said, that Production Control is exclusive to the large firm. It is not, and if sensibly applied can be of enormous benefit to all sizes of firms in achieving optimum production.

Generally speaking, the information required to enable Production Control to operate is available to a lesser or greater degree in most firms. Setting up Production Control is a matter of using this information to the best advantage. And this can be achieved by concentrating its flow into one centre which, if you wish, could be called " The Production Control Office."

The first requirement is that as much Information as possible should be determined before a job starts, not whilst it is running. This information in the form of breakdowns, or parts lists, must then be laid out so as to provide for stock control, progressing, machine and shop loading, and manufacturing orders.

The Stock Control section will refer the material or component lists which form the requirement to their Stocks, Ordered and Requirement records, and will indicate on these lists whether there is sufficient material on hand, or whether it has to be ordered, and action will be taken in the latter case. According to the Information provided by Stock Control section relating to delivery dates, etc., which has, in turn, been received from the Purchasing Department, the requirements will then be loaded on the Machine or Shop loading Schedule, and the Progress Department will also at that stage begin their material progress according to the dates which have been provided.

The build-up of load must not be a haphazard allocation of load to a capacity which is based purely upon the theoretical figures of Departmental or Shift hours, even though an allowance may be made within these figures for varying contingencies. It must be based on departmental hours related to machine hours worked within the departmental figure. If this is not done, the shop will only be loaded accurately in theory, in practice it may be over- or even under-loaded. This, of course, applies mainly to batch machine shops.

After the machines have been loaded and the detailed schedules have been prepared according to this basis these will be issued to the Manufacturing Order Section, to the Progress Departments and to the Shops.

From the schedule the Manufacturing Order Department will prepare the necessary instructions to be issued to all departments concerned in accordance with the dates quoted on the Schedule, and any Engineering or Material information available on Parts and Material Lists.

In the meantime the Materials will have been flowing into Stock, and as these arrive an Advice of Receipt will be passed by Stock Control to the sections interested which will vary according to the particular Works. On the dates specified, and providing Material Advice Lists have been received and tools are available, the Manufacturing Orders will be released to the Production Departments for Production to proceed.

These documents should be released so that when they are placed in the hands of the foremen, the three conditions which determine Production have already been established :—Capacity (facilities), material, and tools.

The Manufacturing Order Set should have been prepared in such a manner that a Material label has been provided as a part of the Order, so that when the request is made to Stores for the Material which has already been advised, this identification label can be attached to the batch of work so as to follow it through all stages of production. Under no conditions should the stores be allowed to issue materials or components without an identification label of this nature.

As the various stages of process are completed operation by operation, a document should be released to the progress clerk who should be located in the foreman's office. This ticket will then enable the schedule to be marked in some manner so as to indicate that the job has reached a certain stage.

In the very small firm this schedule will also be in the same office as the Load Charts, etc., and having denoted the Progress position of a job the ticket will be used for off-loading purposes.

Where possible either this ticket or a duplicate of it should form the basis of Wage-payment and later provide information relating to machine activity. I should mention that this is the simplest manner by which records of machine activity can be built up which will form the basis of machine-loading. I would prefer, however, in all circumstances where a number of machines or items of plant are in operation to see that each machine is equipped with a simple machine-history card which would give a complete analysis of running and down-time during the shift periods.

A card of this nature does not involve any considerable clerical effort and if the job numbers are quoted on it against its running time, this information provides a first-class check on the accuracy of your rate-fixing. Furthermore, if the down-time is analysed by a simple code sequence, A, B, C, D, which indicate waiting-setter, waiting-material, waiting tools, and other contingencies you have in your possession all the information you need to assess the effectiveness of your progressing and scheduling, etc.,

It so often happens that a simple analysis of this nature reveals immediately that a shop which is apparently working at full pressure is losing thousands of hours in the course of a year due to the fact that material delivery dates were not being properly scheduled and the resulting increase in production by virtue of the fact that this condition, by being known, can be rectified, is in some cases quite astonishing.

This card can also be used for another very useful purpose by using the reverse of it for laying out the jobs for each machine so that setters and chargehands have a complete guide as to what is required from them during a given period within the framework of the main schedule. This is particularly useful, too, if the agreement of the progress man is sought as each card is being prepared, for it places the chargehand and the setter in a position which enables them to resist the jockeyings of progress men to undertake panic action. Not only this but it also puts the progress man on his toes because he is himself committed to the individual machine schedule.

By the above means there will be a complete tie-up in a very simple way between Load and Off-Load, Rate-fixing and Performance, Schedule and Achievement, and finally, Promises Against Actual Deliveries.

This may all sound very simple, and I can assure you that for the small firm it is very simple, although naturally local conditions and the factors of war production mentioned above will make for countless complications which are irritating and often difficult to deal with.

The bigger the production unit becomes and the larger the number of different jobs it is called upon to handle, then the more complicated becomes the machinery and method of production control. So long, however, as we bear in mind the fundamental principles which have already been enunciated, and so long as we never allow ourselves to be divorced from the fact that Production Control is bound up in being able correctly to reflect the physical movement of machines, labour and material, then we shall be approaching our problems from the practical viewpoint.

Some Implications of Production Control.

I should like now to pass to some of the implications of Pro duction Control.

I have already referred to the growth of organisation in recent years, and it would be foolish to close our eyes to the fact that this growth must inevitably continue. In a recent book a Mr. James Burnham has examined this growth of organisation in great detail and very scientifically. This book is called " The

Managerial Revolution," and its main thesis is that the future is one in which the Managers will take control. That Socialism is not the form of society which will develop from the vast social changes taking place to-day. Mr. Burnham then argues as to the social revolutions in Russia and Germany, and makes the case that they are in reality Managerial Revolutions, and that the Managers have taken power. Mr. Burnham may, or may not, be right in his contemporary analysis of these political events, but irrespective as to whether he is right or wrong there is a great deal in this book which is particularly significant for those persons who are concerned with industrial organisation.

We cannot yet foresee the solution to the problems of distribution and production which have been contributory factors in bringing about this, and the 1914 war, and I think it is an important indication of the confusion which exists in all quarters on this subject that so far no one has been able to point to the machinery and economics which will facilitate the production of wealth at the close of hostilities.

There is a great deal of discussion in all quarters which is a reflection of basic necessities which speaks of planning and organisation and management. The whole of this address has been concerned with showing that increased complexity must lead to increasing specialisation. The problems which face society are political problems. And I think from our point of view we would be well advised to draw a clear line of demarcation between that which is political and that which is industrial. Except in one respect—the significance for us in the increasing organisation which we can see developing on every side is that to plan and to organise and to manage means that there must be competent Planners, Organisers, and Managers. And one of our jobs, as an Institution concerned with Production Organisation, is to train our engineers so that they will provide a nucleus from which this new and increasingly important body of administrators can be drawn.

The particular part which those concerned with Production Control in its relation to this wider field of organisation should play is to develop a technique which is capable of handling and co-ordinating engineering productive resources to the best possible advantage. This technique within this larger framework should be flexible and simple. A great deal of research is necessary if we are to develop a series of formulae which will cater for the constantly changing conditions which will inevitably arise. We must cultivate a new approach to Production Control, and we must free ourselves from the methods which make planning into guesswork, progress into chasing, and every difficult path into the line of least resistance.

Discussion

MR. PRICE, Chairman of the Production Control Sub-Committee, who opened the discussion, said : I have listened to Mr. Appleby's paper with great pleasure and interest ; the territory covered and the way in which it has been dealt with reflect great credit on Mr. Appleby, and enable one to understand why previous discussions of the paper in the provinces have been so successful.

It is over twelve months since a meeting to discuss production control was held under the chairmanship of Mr. Kipping, and those who attended it will remember that Mr. Dyson, Mr. T. G. Rose and other members gave us very useful advice. Since that date considerable strides have been made by this Institution, and the subject-matter has been developed into a national project. The need for production control has been realised in the very highest circles, with the result that the British Standards Institution and our own Institution have undertaken the task of providing information on a very wide basis.

Mr. Appleby has read what may appear to be a formidable paper, but, having had a year's discussion of the subject, I can assure you that it is not as difficult as at first sight it may appear to be. For a long time production control has been allowed to remain in the background, without sufficient emphasis ; but we have only to consider the invasion of North Africa and the success of the Eighth Army to realise that they represent not only a wonderful feat of arms and of generalship but a remarkable achievement in planning, and, as Mr. Appleby has said, planning is one of the main functions of production control.

It is realised by the Services that, for an operation to be successful, planning must play an important part and take its correct place in the organisation, and personnel are detailed within each unit to do this work. It is now being realised by industry that planning is essential to ensure that full use is made of labour—particularly with the diluted labour now available—machines and material, and to see that contracts are dealt with at the right time and in the right quantity and here again personnel are required to carry out the planning function.

I would draw the attention of the Ministry of Labour to the necessity of providing this type of employee. In many factories to-day labour is being withdrawn from the planning function to operate in a different capacity, perhaps within the same plant. If this trend is allowed to continue, all attempts to introduce effective production control will be defeated. I hope that the British Standards Institution, when dealing with factory office systems

and the conservation of man-power, will emphasize this point. In the technical departments of industry a large amount of the detailed work is carried out by girls and juniors, and these juniors are now being withdrawn and directed into the actual production unit. When the attention of the Ministry of Labour was drawn to the fact that this meant that skilled men would have to do their own detailed work, the answer was : " Then we shall have to take those chaps as well." There is need for recognition of the fact that the planning function is just as important in industry as it is in the Services.

Mr. Appleby dealt with the subject of machine and labour utilisation. We go to great trouble to secure the accurate loading of our machines, but we ought also to go to the same trouble to unload them. One often finds that machines are loaded up 100% and according to the load board they remain loaded 100%, whereas actually the shop is crying out for work, due to the fact that the machine jobs are completed but the work is waiting for a finishing process, such as plating or enamelling.

A further point is the need to maintain a correct balance where both machine labour and assembly labour are employed. The output of the machines is controlled by machine speeds and feeds as well as other things, but assembly labour is controlled mainly by its own effort, coupled with the rate-fixers. An awkward situation arises when assembly labour is producing above schedule : it is just as wrong to produce above schedule as below it, for it means that there will be idle assembly labour, and the machine shops will be blamed for not keeping pace with them.

It is no use laying a great deal of emphasis on production control, however, unless the information on which production control is built up is accurate. This brings us to the operation planning sheet, and I think that considerable stress should be laid on the need for accurate information from the production engineering department, as this is the very foundation on which the structure of production control is built.

Colonel Briggs (Ministry of Production) : I am sure that Mr. Appleby is teaching the right doctrine, but, though I should not like to say that he is a voice crying in the wilderness, I do feel that he is speaking to a world which is not entirely converted.

There is, perhaps, just one cautionary note which should be struck. Some years ago, someone said that there were two Armies : one was the Army which existed in the minds of the General Staff and the War Office in planning for the future war, and the other the Army which got up in the morning, washed, shaved, had breakfast and went on parade. I feel that we should be careful to see that the two production armies are really one, and that there is really

a practical relation between the work in the office and the work on the shop floor.

In that connexion, I should like to say a word about the B.S.I. Committee. I had a hand in forming the B.S.I. Committee on Factory Office Systems shortly after the Ministry of Production started, and that effort is now growing like a snowball; it is most encouraging. It started a year ago, but, owing to lack of control over the production of the printers, the first booklet has not yet appeared, although I am told—as I have been told for about a month—that it will be out in the next day or two. I am sure that the work of the Institution of Production Engineers in producing this booklet will have a very beneficial effect on production, not only now but after the war. The advantage of having that work, which is, of course, the work of this Institution, published through the B.S.I., is first of all that it has had the approval, and perhaps the slight criticism, of the main Factory Office System Committee, which includes representatives of all the interests concerned, and secondly it has had the approval of the Executive Committee of the British Standards Institution, which includes a very large range of interests, industrial and scientific. It will therefore go before the world as a really authoritative document, and not, as might otherwise be said, the production of one interest only.

MR. ALBU: In the past, the choice of people to perform the function of production control has been rather haphazard, and in the future, as I am sure Mr. Appleby will agree, very much more attention must be paid to their selection and training. What I want particularly to ask him about, however, is the control of the production controllers. What I mean by that is this. Most engineers have some idea of how to check the technical functions in a factory, but one of the greatest difficulties in a large organisation is to ensure that what is laid down as the schedule of operations is in fact carried out. It is possible to ensure that the schedule of operations for machining, assembly, and processes necessary to achieve the final condition of the product is carried out by measurement, tests, inspection and so on, but how does one ensure that a *system* is being carried out either correctly or in such a way that it is not in fact clogging the processes which it is designed to facilitate?

The larger an organization becomes, the more bureaucratic it tends to be. Now, bureaucracy is not in itself a bad thing, but it has got a very bad name, and it has got a very bad name because it has not become efficient. Mr. Appleby has pointed out that the production control department, like the other departments of the factory, must be responsible to the "top management," as the Americans call it, but how is the "top management" to judge whether the production control is itself efficient? To judge by

results is not enough; we want to know where mistakes are occurring and whether the system is working in the best way.

With regard to Mr. Appleby's last remarks, about the future importance of planning from the point of view of management, the present interest in production control is due to the fact that we are trying to produce to capacity, and all our resources are, or should be, fully employed, and if anything overloaded. There is a danger that that condition may not exist after the war, in which case the interest may disappear, and the whole development of planning in industry and of production control in industry may be handicapped. I believe that that would lead, in 25 years' time, to the same sort of situation which we have now. There are many plans for maintaining full employment after the war. I believe that unless we are able to production-control the whole of industry in such a way that it is really efficient and produces the goods, the stresses which will arise under conditions of full employment—similar to those which we know exist in war-time—will give rise to such terrific political complications that there will be a breakdown. In other words, whether we are able to continue to have the full utilisation of the resources of industry for maximum production for the highest consumption—and if that is not the objective of production engineers, I do not know what is—will largely depend on the success of the means that we use to plan and control production, both nationally and in particular in our own factories.

MR. MOORE: My present business in life is to deal with the requirements of factories for machinery, and I find that among the factories which I visit there is no agreed opinion about efficiency, and I also find that the efficiency varies from about 60% to about 85%, according to the class of work. In some cases a product is being made at 65% efficiency when in planning the loadings an efficiency of 100% has been assumed, and there are complaints that the management, when doing their planning, do not take account of discrepancies which are bound to occur. What should be produced in 100 hours is worked out on a mathematical basis, allowing so long for one operation and so long for another, but it is never in fact produced, because no allowance has been made for contingencies. It is most important to work out those contingencies in all the various departments, so as to ascertain what their actual production is likely to be, taking into account lateness, holidays, unforeseen circumstances, not starting to time, stopping too soon, the fact that female labour powders too often, and so on. If all those things are taken into account it is possible to arrive at some average, and I think that if Mr. Appleby had dealt with that subject we should have had a much better understanding of how production control finally worked out.

MR. HANSCOMBE: If Mr. Appleby was a member of a firm who were proposing to set up production control, would he advocate that the man who was already in charge of planning and progress should take charge of production control as well?

He spoke of the purchasing department carrying their own progress. From my experience, that seems to lead to duplication of work, because the ordinary factory progress, which is concerned with progressing outside suppliers in the form of piece parts, is interested in those parts as applied to a specific job. The purchasing department, who have their own progress, are not concerned with specific jobs but with lists of parts which are coming from a number of different suppliers. They do not know the specific contract to which the parts are applied, and so it is necessary for the works progress to chase the purchasing department progress, and duplication results.

MR. WEBB: While I appreciate this paper very much, Mr. Appleby has missed one of my greatest difficulties, which is that when working to a pre-planned schedule it is necessary to have from the sales side a definite statement of what they require in the coming months, and perhaps year. We have a certain capacity of machines, which we load, and we make allowances for contingencies, but then the management or the sales department come along and say "We want to have this ready in a month's time," or "We want this put through at once." We cannot dictate to them. Does Mr. Appleby suggest that we should be in a position to do so in production control?

MR. BROADBENT: It would appear that a department dealing with production control may be either supplementary or complementary to existing works departments. At what level of authority would Mr. Appleby suggest that the head of a production control department should be rated from an organisational point of view?

MR. BURNETT: Mr. Appleby refers to production control as "organised common sense." I have found that anyone in charge of production control has to be a first-class production engineer, accountant and commercial man. One of my biggest problems in planning, a problem probably peculiar to a general engineering business, is planning against tenders, and knowing whether to reserve capacity in the future on the expectation of getting the contract. We deal with that problem purely by guesswork; we try to sum up the customer and the type of work, and, according to whether we think we shall ultimately get the contract or not, we make a definite reservation or ignore it altogether. It is a big problem in planning to know what one's future commitments are going to be, because apart from the actual orders it is necessary to consider the probable orders.

Another point to which considerable attention should be paid is the maintenance of plant. That side of the organization must have very careful attention, because undue breakdowns will cause definite loss of capacity and resultant negative performance. In that connexion, I think that managements in general should pay more attention to a definite plant replacement policy. Most managements appear to believe that plant can go on for ever and still produce the same amount of work, but that does not happen in practice.

On the question of taking contingencies into consideration and working out an efficiency for the plant, if you compare the hours allowed with the hours actually taken you can arrive at an efficiency ratio, and from that you will know what to expect, and can judge whether you ought to get more or whether you are already doing very well.

MR. WILLSMORE: It seems to me that Mr. Appleby missed one of the main features of production control; he seemed to imply that production control is essentially a matter for engineering firms and not to be applied elsewhere, as, for example, in the coal industry. I feel that anyone in the coal mining industry—I am not in it myself—would flatly deny that assumption, with its implication that the management said to the miner "Go downstairs and bring up what you like." I believe that in the coal mining industry they do a certain amount of control and planning, though perhaps the trouble is that they do not do enough.

What I think has to be considered is the type of manufacturing carried on in an industry—whether the industry runs a continuous process, whether it runs as a jobbing shop where every individual order is different, or whether, as is the case with most firms, it happens to be half way between the two, with batch production. I think that the importance of this is that many firms, not being clear exactly where they stand, and seeing other firms adopting this or that system or gadget, say to themselves "We must have that," and much of the present interest in production control is, I feel, little more than that.

It seems that production control as such is beginning to fade out of the limelight in favour of quality control. There are many firms running continuous process or large batch production who use the complicated curves of error to give them some limits within which they watch every individual piece off the machine to detect falling off in quality demanding executive action before it leads to trouble, and several firms to whom this particular "trick" is not at all suited nevertheless have seen so much in the papers about it that they feel they must do it too.

I feel that this machine scheduling problem, which seems to worry people so much, is very much in the same camp. There must be many firms who, during the war, are making a product which does not impose a uniform, balanced load on their plant and facilities, and in fact those engineering firms who do have a demand on all their equipment equal to its potential capacity are in the fortunate minority. The others have much more than they can handle conveniently on certain processes, with other capacity on which they have no chance whatever of " breaking even " or even running within 10%. It seems futile to keep very elaborate machine records for every machine in the place, when the implications of the work are that some of those machines must be idle for a large part of their time.

It would seem, therefore, that before this machine schedule activity and loading chart business starts there should be somebody who will decide what are the bottle-neck machines or what machines there are where the demand exceeds the capacity. That would direct attention to what alternative machines could be used for the processes in question. Then, having decided that there are, say, six processes which are going to control the question of whether the job can be done or not, records and statistics can be confined to those, without worrying about the others. We should not then have the terrific business of setting up a schedule for every machine in the place and then getting a new contract and having to re-schedule them all.

Mr. Edwards : I think the Supply Ministries could give more help than they do in this matter of production control. In most cases the contracts given to the smaller firms are too small, and are not in long enough sequence to permit of complete production control ; the toolroom becomes overcrowded with work, and the firm has therefore to put work out and be dependent on deliveries, with consequent delays. If the Ministries could allocate work in such a way as to give a fair continuous run, instead of continually changing over, it would be possible to plan in advance and give more stabilized delivery than at present. One would then have adequate time in which to plan the next job. At present a job comes in which will last only three to four shifts on automatics, and then tooling has to be got ready for a completely new job, and the job may be stuck in the toolroom waiting for a fixture and the machines are idle while awaiting setting.

Mr. Appleby (in reply) : Mr. Price said that accurate information is needed for production control. Ideal conditions for production control cannot always be achieved, and we all know that on numerous occasions when we receive the information in the drawing office or on the I.T.P. or on the tender we have not got all the technical data required to lay out the opereation sheet ;

but that does not prevent us introducing the greatest measure of control at a later stage, and putting the information into the shops if necessary on a provisional basis, including temporary rates, temporary tools and so on. I mentioned in relation to wartime production the need for improvisation.

I should like to make one comment on the booklet which Colonel Briggs mentioned, and which he said had been approved by the Executive Committee of the B.S.I. If I may speak for Mr. Price, as representing the Production Control Sub-Committee, I should wish to say on behalf of the Sub-Committee and of the Institution generally that we are extremely grateful for the help, criticism and comment which we have received from the B.S.I. in the preparation of this booklet.

Mr. Albu raised the question of the training of personnel for supervisory grades. I do not propose to say much about this, but it is obvious that at the moment one of the greatest needs in industry, particularly in this country, is for more comprehensive methods of and facilities for training in an organised manner the whole of the personnel who are going to be up-graded into managerial positions. It is pleasant to know that an organisation with which Mr. Albu is intimately connected is concerned with building up an association of managers, so that they can get together and do something about this. There are other bodies, such as the Institution of Industrial Administration, which have done some work in this direction, and in particular credit should be given to Mr. T. G. Rose, who has given so many lectures and addresses at schools in the Midlands on this subject. Moreover, this Institution in its examination syllabus includes organisation and production control as one of the subjects.

Mr. Albu also raised the question ot the control of the controllers, and I think that is bound up with the question of trying to assess some standards of performances. I do not think that it is possible to say that the efficiency of paper work itself can be measured. Production control, as I said in my paper, is a means towards an end, and that end is maximum production. Only by relating production control to its effect on any aspect of production shall we be able to say whether or not it is effective. In addition, of course, to the outflow of information which starts production going there should be a return flow of information which shows where variations from the plan are occurring; and the acid test of production control is whether the plan is being achieved. That is the standard, in the same way that an estimate would provide the basis for a standard cost, and budgetary control may provide the basis for standard financial performance over the course of a year. At this stage in the application of production control, however, there is far too little experience of the

type of standards which can be imposed on any aspect of production organisation to say whether it is operating with the maximum effectiveness or otherwise, but it is possible to show by trends whether the movement is in the right direction. To take a simple case, if a machine shop was losing 700 hours a week, and by the introduction of production control the loss was reduced to 600, you would know that you were moving in the right direction; and the thing to do is to keep moving in the right direction.

Mr. Albu also mentioned the question of the future of management, and asked whether there would be the same pressure in post-war conditions to maintain or improve efficiency as there is to-day when we are linked up with the State organisation. As I said in my paper, no one has yet been able to tell us what form of organisation we are going to have after the war; on the other hand, there can be no doubt that the whole of industrial and commercial and State organisation is bound to increase. The curve over the past fifty years, and even over the past two hundred years, has been continually rising, and I do not think we can deny the significance of that very important fact.

How far it will be possible in a controlled economy—if we are to have a controlled economy—or in a semi-controlled economy to establish standards which will determine whether we are achieving the maximum utilisation of our productive resources is another matter, but we must not overlook the fact that even with the best organisation for the international distribution of materials and goods there is bound to be an element of competition if we are to produce the goods in the factories and in the countries most economically suited for producing them.

Mr. Moore raised the question of efficiency, but I should like to ask, what sort of efficiency. He said we had 60% to 85% efficiency from industry. I cannot say much about that until I know to what it is related. If he is concerned with machine efficiency in relation to the facilities available to operate machines, I should say that machine efficiency is below 60% rather than up to 85%, and that only in the productive processes where the operations are flowing, as for example in fuse production, or in large-scale mass production where a plant is specially laid out for a particular job, and there are no modifications and no shortages of material, will the efficiency go much higher. In the general batch machine shop, with all the conditions which are being imposed to-day, I should say that the efficiency of machines and operators is below 60%.

I did try to cover the question of contingencies, but obviously all contingencies cannot be covered in detail, and therefore on estimating and rate-fixing it is essential that we should provide

for the unknowable conditions, the variables which are outside our own control. I should also like to take the opportunity, while we are on this question of rate-fixing, of saying that we obviously do not know very much in this country at the moment about what a person is capable of doing in the course of a day's work, and until we considerably expand our knowledge of the physiological and psychological possibilities of individuals we are obviously going to be limited in the full production to which Mr. Albu has referred.

That again impinges on the question of the training of foremen, and so on, and indeed the whole question of vocational selection, psychological tests and so on applied to industry generally so that we can put people into the jobs which they are most capable of doing. I read a paper the other day, I think in the *Journal* of this Institution, on the training and selection of operators, and it was there shown that where there was no proper method of selecting people to do a particular job the labour turnover was very high and very uneconomical. Obviously in a condition of full production such as we have to-day, and such as we hope that we may have after the war, a high labour turnover detracts considerably from the amount of production per man-hour in total.

Mr. Hanscombe asked whether I would recommend putting in charge of production control, in the event of a production control department being set up, a man who at the moment is in charge of planning and progressing. My reply is that if a man is already in charge of planning and progressing he is very nearly the production controller already, and therefore the question does not need answering; but I would first ask whether he is doing the planning and progressing successfully.

He also raised the question of the purchasing department carrying the responsibility for their own progress, and said that he did not agree, because he thought that there was duplication of function between the purchasing progress and the internal progress in the works, and that the purchasing side did not know the specific jobs which had to be progressed from time to time, and therefore one progress man would have to get in touch with another, and so on. But what happens in any factory to-day? The assembly progress man will link up with the machine-shop progress man who progresses the whole of the work through the machine shop, and this is not duplication but simplification and specialisation. If there were three or four assembly shops with a progress man in each, it would be undesirable to have four progress men contacting the same foreman. With regard to the progress man in relation to purchasing, present conditions differ from normal, because many of the commercial relationships which purchasing and

financial departments build-up in peace-time, and which were intimately connected with company policy generally, do not exist to-day because of the machinery of the controls and the ways in which materials and parts are made available in the factory. On the other hand, that may be an argument for letting the internal progress people deal with outside progress. I said when I mentioned this point that I did not wish to be dogmatic about it, but I still feel that I would make the purchasing agent himself the man responsible for getting in touch with the controls, with the various Government departments concerned, with the various manufacturers linked with the controls, and with all the various manufacturers with which he may be concerned on sub-contracting, because it is still an outside job, and is concerned with specialised work which is rather different from the rest of the work involved in inside progressing, and which is a question of schedules, shortage lists and so on.

Mr. Webb said I had missed out the greatest difficulty which he encountered, and that was getting from the sales department a monthly requirement or a yearly requirement. I do not know with what organisation he is concerned, but one of the conditions under which we are working to-day is that it is not always possible for the sales department to have monthly or yearly requirements. If a firm is still engaged on the type of work which it was doing in peace-time, it may be possible for it to budget for a year, and everything will be straightforward and you can order your material and so on, but there are bound to be variations and the budget is only a general indication. In the majority of cases to-day, particularly with sub-contracting firms, it is not possible to know what the forward load is, and, due to the varying needs of the Services, due to the need of keeping their technical development as far ahead of the enemy's as possible, it is impossible to lay down requirements ahead for any particular works. In some cases, such as fuse production, shell production, munitions production, and in some cases tank production on the more standardised jobs, a long-term programme can be laid down and the problem is resolved ; but, if it is not, then the position has to be faced.

Production control does not mean saying " If we cannot have a sales programme, we can have no production control." What it says is " We must have as full a knowledge as possible of the conditions under our control, so that in these varying circumstances we know how best to operate them." A nineteenth century philosopher has said that freedom of choice arose from a knowledge of the laws of necessity, and of course that applies in organisation ; the greater our knowledge of the necessary conditions which must apply, and the greater our knowledge of what is happening,

the more freely we are able to make our choice of any particular line of action.

Mr. Broadbent raised the question of the level of authority which the production controller should have in any particular works. There again it is not possible to lay down any standard which can be rigidly adhered to, but I think that it is generally true to say that production control, as the organising factor in industry, should take its place on an equal level with the other three factors—the labour factor or works control, the actual production; the engineering factor; and the inspection, accounts and purchasing, the commercial factor.

Mr. Burnett referred to all the qualifications which a production controller must have. As I emphasised in one of the papers which I read to the Sections, the man most competent to carry out production control is the man who has not only organising ability but also engineering and technical knowledge of the work which he is handling; but in practice it is necessary to accept compromises and it is never possible to get in any one individual all the qualities which would make him the most suitable man for the job. If you can find an engineer with the necessary organising ability, he is obviously best suited for the work; but if you cannot, then, as production control is predominently a question of organisation, the engineering aspect of it must be sacrificed.

Mr. Burnett mentioned planning against tenders, and I have dealt with that point; but he said that it was based on guesswork, and I do not agree with that. It is based on guesswork relative to absolute knowledge, obviously; in that we do not know everything about everything, everything becomes guesswork; but in making what I would call a "guesstimate" one has arrived at a basis for laying down a programme, and by that programme, no matter how wide of the mark it may prove to be in practice, a standard has been established on which it is possible to work. As for reservation of capacity, if Mr. Burnett can suggest an alternative to reserving capacity against the possibility of an order we shall be very pleased to hear it; but it is not possible. It is necessary to reserve capacity in anticipation of an order being received. It is better to be anticipating a definite order than never to know from one day to another whether you will receive an order or not, which is the case with the very small firm which has to deal with sub-contracts on a day to day basis.

Mr. Burnett also spoke of the maintenance of plant, which, as far as production control is concerned, is mainly a technical matter, though the management is concerned with the financial policy of replacement which is laid down. Like all other factory activities, it does impinge on production control, because the

effective maintenance of plant will influence the capacity which is available.

Mr. Willsmore suggested that I had missed one of the main features of production control, and had made it the prerogative of engineering firms only. I did not say that; what I said was that "production control" was a term which had arisen in the engineering industries. It might be said that production control would apply to the large teashops of Lyons', to Selfridges and so on, where there were big problems of organisation, but it was not called production control, because a different technique was needed. The fundamentals of organisation would apply equally in the coal mining industry, but there would probably be a difference of technique, and it was that difference of technique which differentiated other forms of organisation from production control.

Mr. Willsmore also mentioned the difference between batch production, continuous processes and so on. In my paper I said that even in the field of production control as I limited it it was necessary to consider groups which demanded special treatment, and obviously batch production would be controlled differently from a continuous process. The production control of fuses is not a production control problem at all in the sense in which I am dealing with it, because it is simple and straightforward; but the control of a batch production shop, where the jobs changed from day to day and one never knows what one will be getting in from one day to another, is a totally different and much more complex problem to handle.

I am inclined to agree that such things as load boards and visible systems tend to overshadow what production control really is. Production control is not load boards or visible systems or other gadgets; it is the organisation which will make the load boards tell you what is really happening, and not be merely something which looks pretty on the wall but which never works, so that after two or three weeks nobody bothers about it. By all means instal load boards, but see that you have the proper organisation in the shops and the office to make them represent reality, and instal them only when you are going to get something out of them. Far too many firms to-day instal load boards without any need for them at all.

Mr. Willsmore referred to quality control, which he described as very complicated. In my view, whether it is very complicated or not depends on whether it is justified in the particular circumstances. It does indicate where something is likely to go wrong before it has gone wrong, so that it can be corrected in time.

Mr. Edward's reference to the Ministries and small contracts is outside the terms of reference of this paper. It is obvious that

many firms will be concerned with short runs, and there is very little that they can do about it. The Government departments have been severely criticised in the Press during the last three years for the lack of continuous orders, but they must be given credit for knowing something about what they are doing, and, if there is criticism of them for lack of planning and organisation, I think that we in industry should be very careful about where we turn the limelight when it comes to questions of organisation!

MR. BLACKSHAW: For a long time we discussed whether we should hold any evening meetings, or indeed any meetings at all. The meeting this evening has clearly demonstrated that there is a real need for them. On behalf of the London Committee, I should like to thank all those who have supported us, and to say how much we appreciate it.

I ask you to accord a vote of thanks to Mr. Appleby for his excellent paper and for the very able manner in which he has replied to the discussion.

The vote of thanks was carried with acclamation, and the meeting then ended.

Research Department: Production Engineering Abstracts

(Edited by the Director of Research)

ANNEALING, CASEHARDENING, HARDENING.

The Flame-hardening Process. (*Machinery, April 8, 1943, Vol. 62, No. 1591, p. 365, 6 figs.*).

Flame-hardening must not be confused with carburisation. The only effect of torch-hardening is to harden local portions of any component and it is the difference in structure so obtained after quenching that gives the appearance of a case. Heat induction and heat conduction are equally important; the rate of travel of the torches must be such that burning as the result of too slow a movement, and under-hardening as the outcome of too rapid a movement is prevented. The depth of hardening can be varied from a mere skin to a maximum of $^{5}/_{16}$ in. Farrel-Birmingham saddle-type flame hardening machine. The " straddle " method of hardening gear teeth as opposed to the older method of hardening the faces of the tooth separately. Advantages of this method. The flame-hardening of large components such as gears, pinions, shafts and machine beds is of comparatively recent origin.

A practice which has become quite common is the selective carburizing of low carbon steel and subsequent hardening of small areas by means of the oxy-acetylene flame. Table of steels suitable for flame-hardening. The flame hardening of gears.

Plant and Process Problems, by D. G. P. Paterson. (*Sheet Metal Industries, April, 1943, Vol. 17, No. 192, p. 614, 20 figs.*).

Surface-hardening methods produce a hard external layer by heating the surface only above the critical range, and quenching the heated portion. The main mass of the material remains cool, even though the surface temperature may rise to some 800°C. In the Shorter process the necessary rapid and uniform heating and quenching are obtained by using oxy-acetylene burners, closely followed by quenching jets. Gear hardening by the Shorter process. In the Tocco process the surface is heated by placing over it an inductor block carrying a high frequency electric current. The eddy currents induced in the steel result in rapid heating, and after a few seconds the quenching jets are automatically turned on. Close co-operation is necessary between the metallurgist, the practical hardener and the designer. Gear and hub, showing good and bad designs for heat-treatment. Cracking after quenching may, for instance, be due to non-metallic inclusions or to the persistence of the original coarse " dendritic " ingot structure, which has been inadequately broken down during forging. Steels of identical chemical composition and subjected to the same heat-treatment may show very different degrees of " hardenability " on behalf of different grain size. Grain size control and determination. Tentative standard grain size-charts made by The American Society for Testing Material. Alloy steels. General effects of alloying elements: tungsten, vanadium, molybdenum, chromium nickel, nickel and manganese. Alloy case-hardening steels. Heat-resisting steels. Corrosion-resisting steels. Alloy die and tool steels. High speed tool steels. Hardening high speed steel.

Tungsten raises the critical points, and to dissolve as much as possible of the carbide prior to quenching a temperature of 1250°C. to 1300°C. is necessary. Many examples.

COOLANT, LUBRICANT.

Machine Shop Lubrication, by L. Sanderson. (*Machinery-Lloyd, April 17, 1943, Vol. XV, No. 8, p. 37, 2 figs.*).

Carefully chosen coolants and lubricants enable the cutting tools to give vastly improved service life, but also render an increase in cutting speeds possible. The local conditions, for example, the hardness or softness of the water, have an influence on the choice of coolant. A table gives a comprehensive list of operations and materials for which particular types of coolant and lubricant are suitable, and it will serve as a general guide. Three main classifications of lubricant: (a) cutting oils, (b) water solutions, (c) emulsions. Direction of lubricant. Milling cutter lubrication. Keeping recirculated oil clean. Nozzle dimensions.

JIGS AND FIXTURES.

Air-Operated Accessories Speed Up Power Presses, by Roy E. Hearl. (*The Machinist, April, 1943, Vol. 86, No. 52, p. 1490, 5 figs.*).

Power presses can be hooked up with air controls to take over many of the operations now being done by hand, thus increasing production. Many plants can take advantage of compressed air for power to operate machine tool slides, clamping devices, jigs and fixtures, and other devices. The illustrations show air-operated devices applied to old presses.

Clamping Cylindrical Components. (*Mechanical World, April 16, 1943, Vol. 113, No. 2937, p. 403, 29 figs.*).

Cylindrical bars and shafts have frequently to be clamped, i.e., held by friction in a position where axial or tangential forces cannot effect relative movements between the connected components. Examples are shafts in boring bars, the clamping of collar rings, bar material in automatic machines, and the clamping of cylindrical guiding bars in instruments and machines. The usual clamping devices are wedge, screw, eccentric, clamping by spring action and the flexibility of the material. Their design and a critical review are given in 29 sketches.

MACHINING, MACHINE TOOLS.

Spindles Drilled Faster, by David H. Samuelson. (*The Machinist, April 24, 1943, Vol. 87, No. 1, p. 74, 4 figs.*).

Need for increased production and more floor space led to the use of turret lathes for boring lathe spindles. As a result, production rate was multiplied. The lathe has an extra long bed to hold the work outside of the spindle and to permit using long oil drill bars for the flat drill cutter and adjustable shell reamer. Chip breaker slots staggered on each cutting edge of the flat drill cutters break chips.

The Steinle Centreless Thread Generator. (*Machinery, April 22, 1943, Vol. 62, No. 1593, p. 430, 6 figs.*).

On this machine the work is carried on a rest similar to that used on the centreless grinding machine, the work being positioned with its centre line below the centres of two forming rolls, the distance varying according to the

nature of the job. One of the rolls revolves about a stationary axis, while the other, which is carried by a hydraulically operated slide, is fed inwards to engage the work and apply the pressure necessary for the threading operation. There is no lateral movement of the work during the working portion of the cycle of movements. The rolls are multi-start. Close-up view showing the rolls and hydraulic cylinders. General arrangement drawing showing the essential features of the machine. Operation of the machine. Range of operation.

Small-Quantity Gear Cutting, by C.P.A. (*Mechanical World, April, 1943, Vol. 113, No. 2938, p. 448, 4 figs.*).

Practical notes on teeth milling when generating machine is not available. Tooth proportions. Indexing the blank. Rack cutting. Skew gears. Helix angle. Methods of producing helixes. Cutting helixes. Bevel wheels.

CHIPLESS MACHINING.

Aircraft Sheet Metal Work, by Wilfred E. Goff. (*Aircraft Production, May, 1943, Vol. V, No. 55, p. 219, 32 figs.*).

Production of equipment for Bristol engines. Manifolds and cowlings. Soft metal forming tools. Spot-welded units.

MANUFACTURING METHODS.

Large-Scale Assembly. (*Aircraft Production, May, 1943, Vol. V, No. 55, p. 207, 6 figs.*).

Automobile practice and the aircraft industry. Vega methods for Ventura assembly.

Machining High-Nickel Alloys, by R. H. McCormick. (*Machinist, March 6, 1943, Vol. 86, No. 47, p. 1347*).

Short note on cutting angles, cutting tool materials, speeds and cutting fluids.

MATERIALS, MATERIAL TESTING.

Magnesium, by C. H. Desch. (*Roy. Soc. Arts Preprint, February, 1943, 10 p.*).

A lecture giving a general survey of the subject. Occurrance of Mg; uses of magnesia; a useful account of the common methods of extraction of the metal; effects of alloying elements (including Be); casting and die-casting; inspection of castings; working; machining; inflammability; corrosion and surface protection; uses and design requirements. Individual commercial alloys are not dealt with.

(*Supplied by the British Non-Ferrous Metals Research Association*).

Radiographic Inspection Technique Applied to Special Welding Problems, by D. M. McCutcheon. (*Welding J. Amer. Weld. Soc., January, 1943, Vol. 22, No. 1, p. 16*).

Problems associated with X-ray inspection of various welded sections are briefly discussed. Non-ferrous applications include examination of Al-alloy cylinder heads repaired by welding, and Al spot welds.

(*Supplied by the British Non-Ferrous Metals Research Association*).

MEASURING METHODS, APPARATUS.

Screw Thread Gauges and Gauging, Parts III, IV, V and VI. (*The Machinist, Reference Book Sheets, April 10, 24, 1943, Vols. 86 and 87, Nos. 52 and 1, pp. 1525 and 109*).

Part III. Gauge classification. Gauges used to measure the product. Mechanical gauges. Optical gauges. Gauges for reference.

Part IV. Direction of tolerances on gauges. Temperature at which gauges shall be standard. Measuring pressure for three-wire measurements. Specifications for gauges. Classification of gauges, and gauge tolerances.

Part V. Master gauges. Tolerances. W Gauges. For the inspection of Class 4 product within especially close tolerances. X Gauges should be suitable for inspection and setting gauges for Classes 1, 2 and 3. Y " go " gauges should be suitable for inspection and working gauges for Classes 1 and 2 fits, $\frac{1}{4}$ in. diameter and larger.

Part VI. Thread form of thread plug and ring gauges.

Optical Projector for Measuring Tapered and Square-threaded Screws, by J. W. Drinkwater. (*Machinery, April 1, 1943, Vol. 62, No. 1590, p. 353, 3 figs.*).

Use of a spotting tool to find the start-of-thread point on a tapered screw plug. Set-up of gauge and straightedge on a projector. Use of a pin for square-thread projection. Layout for square threads.

METALLURGY OF STEEL.

Urea Process for Nitriding Steels, by Ray P. Dunn, W. B. F. Mackey and Ralph L. Dowdell. (*Machine Shop Magazine, April, 1943, Vol. 4, No. 4, p. 76, 6 figs.*).

Tests on three steels were described and an indication given of the relation between the nitriding temperature and the characteristics of the case depth when using synthetic urea as the nitriding medium. Urea was selected for use in this research because it was known to evolve ammonia upon heating, was cheap and was easy to handle and store.

PLASTIC MATERIAL.

Low-Cost Dies for Aircraft Parts, by B. Schlenzig. (*Machinist, March 6, 1943, Vol. 86, No. 47, p. 9 of inserted section on Armaments*).

An illustrated account of a number of dies of plastic and semi-plastic materials, such as Masonite die stock or Bakelite, for the press-working of Al alloys. These relatively short-lived dies are eminently suitable for many aircraft parts, designs of which rapidly become obsolete.

SHOP MANAGEMENT.

Employers' Responsibilities under Post-War Industrial Conditions, by G. Preston. (*The Cost Accountant, February-March, 1943, Vol. 22, No. 3, p. 63*).

A specific series of suggestions for the motor car industry as instance. The need for individual unselfishness. The spectacle of annual planning for increased targets of production, and sales at lowering prices in the period between the two great wars. Production was seasonal, or at least there

were many periods of partial employment. When below normal rate, managers who failed to turn employees away were classed as weak or inefficient. The implications of balanced production. The smaller production firms up to 100 employees are in many ways better able to retain continuity of employment. The target or annual budget problem. Each normal factory production capacity should be measurable, and previous selling prices and quantities sold and costs disclosed. Proposal to constitute a Government Advisory Committee. A body with advisory powers only, decisions being in the hands of an Official appointed from the Ministries of Transport, Labour and National Service. The Official should have authority to send experts to investigate and report to him such cases where it seems necessary for him to do so. Their report should be confidential and should state : (a) whether the company is, in their opinion, entitled to produce, e.g., cars or lorry units (or component sets) in the quantities and at the prices applied for. (b) That the wage records reveal reasonable continuity of employees' services. The official concerned would then issue the quotas for each firm for quantity of cars, type and amount of labour permitted during the forthcoming season. The " Holidays with Pay " scheme versus a Profit-Sharing scheme. The suggestions are mainly intended to tide over the difficulties of the transition period after the war.

SMALL TOOLS.

Reamers—How to choose them and how to use them, by Arthur H. Korn. (*The Machinist, April 24, 1943, Vol. 87, No. 1, p. 76, 14 figs.*).

Use of hand reamer limited. To work where only a few thousandths of an inch of stock must be removed, and where, at the same time, no great cylindrical accuracy and fine surface finish is required. Stock allowance for reaming. Reaming on a drill press. Avoiding conicality. Aligning holes for bearings. Line reaming.

The Repair of Drills by Welding. (*Engineering, April 23, 1943, Vol. 155, No. 4032, p. 327, 3 figs.*).

The actual operation is carried out by hand and involves the precise alignment of the broken parts. This is effected, in the case of the smaller drills, by mounting each of the broken parts in a separate headstock. For welding, the atomic-hydrogen arc process, for which Messrs. Metropolitan-Vickers Electrical Company, Limited, Manchester, manufacture the equipment, is employed.

SURFACE QUALITY AND TREATMENT.

Hard-chromium Plating, by A. J. T. Eyles. (*Mechanical World, April 30, 1943, Vol. 113, No. 2939, p. 459, 18 figs.*).

Chromium plating has three distinct kinds of commercial application : (1) Resistance to wear. (2) Resistance to corrosion. (3) For decorative purposes. Model equipment for hard chromium plating. Metal cleaning equipment. Examples : Chrome plated reamer. Chrome plated plug gauges. Chrome plated drawing dies and punches. Chrome plated worm shaft. Chrome plated crankshaft.

Electroplating on Non-Conducting Materials, by E. G. Acheson, Ltd. (*Machinery, February 25, 1943, Vol. 62, No. 1585, p. 210*).

Non-conducting materials (wood, plastics, cardboard) can be given conducting graphite coatings (colloidal graphite suspended in a mixture of

potassium bichromate and gelatine is recommended), if necessary this coating can be waterproofed with a thin coating of wax, and then the usual metals plated on in the usual way.

Spraying Inside Shells, Tubes and Containers, by George Montgomery. (*Sheet Metal Industries, April, 1943, Vol. 17, No. 192, p. 630, 7 figs.*).

Demands created by the war have made many changes in the design, application and use of all types of spray equipment. Spray guns. Extensions to reach some almost inaccessible places which otherwise would not be coated, e.g., shells, burster tubes, oxygen tanks, petrol tanks, cartridge cases, tracer cavities, bombs, incendiary bombs, aviation engines, truck engines, transmission housings, differential housings, tubes, pipes, battery cases, small compartments, radio parts, aviation wing sections, dies, conduits, manifolds and oil passages. Diagram showing internal spraying. Technique of internal spraying. Air versus fluid pressure. Special spray guns. How to solve troubles. Check the paint first; then check the extension alignment before condemning the equipment. Most troubles are caused by the human element.

Metal Cleaning in Wartime, by H. Strow. [*Monthly Review* (*Amer. Electroplaters' Soc.*), *December, 1942, Vol. 29, No. 12, p. 995*].

Summary of methods now in use for cleaning in preparation for plating, anodising and welding.

(*Supplied by the British Non-Ferrous Metals Research Association*).

WELDING, BRAZING, SOLDERING.

How to Spot Weld Aluminium. (*The Machinist, April 24, 1943, Vol. 87, No. 1, p. 82, 2 figs.*).

Correct electrodes are the key to consistent welds. How to choose and clean electrodes. How to test the finished weld. Sample welds for testing. Determining weld strength. Designs for spot welding.

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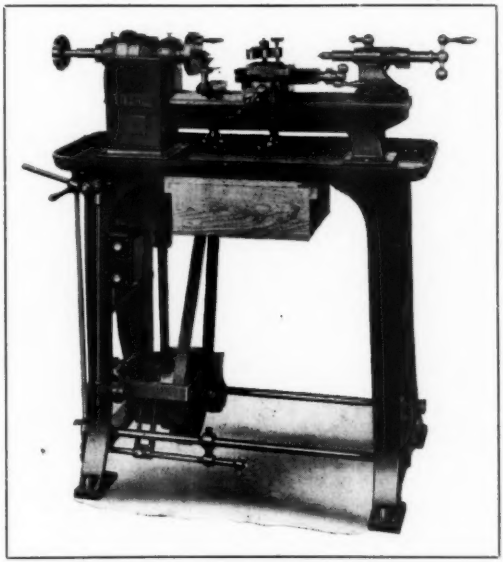

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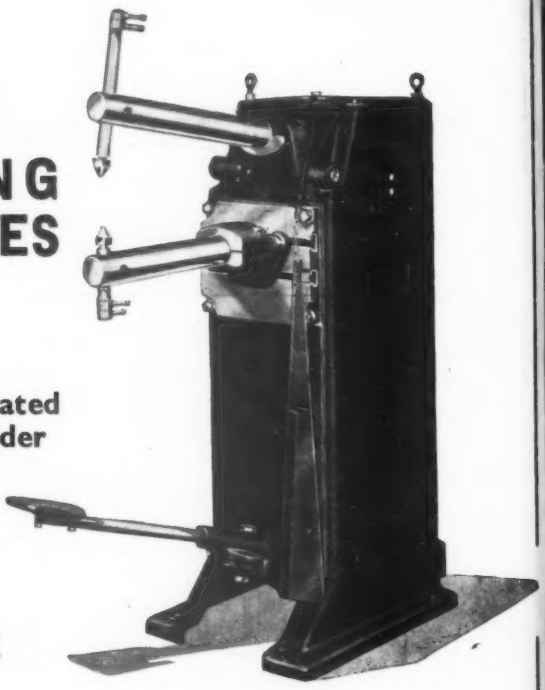

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